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Saving the Earth with Physics: The Important Role of Science in Overcoming the Climate Crisis

Riris Arisa* and Muhammad Minan Chusni

Physics Education Study Program, Universitas Islam Negeri Sunan Gunung Djati, Bandung, Indonesia

*ririsaraiza03@gmail.com

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Abstract

Global warming is one of the most pressing issues of modern times. Rising Earth temperatures have serious consequences for life on Earth. Physics plays an important role in fighting global warming with various principles and applications. This article discusses physics's important role in overcoming the climate crisis and building a more sustainable future. The method used in this research is a literature review, which collects and analyzes various reliable sources, such as scientific journals, research reports, and mass media articles relevant to global warming and physical science. Where the journals used as references for obtaining data were 15 journals consisting of national and international journals. The article's content includes understanding the mechanisms of global warming through physical principles, developing renewable energy technology, increasing energy efficiency, mitigating the impacts of global warming, and increasing public awareness. Understanding the causes and effects of the climate catastrophe and creating ways to deal with it depends heavily on the physical sciences. Understanding the climate system and creating innovative technology to assist in lowering greenhouse gas emissions are two areas in which physicists have made significant strides. Still, much work needs to be done. Physicists must keep working to advance our knowledge of the climate system and create more cost-effective and efficient technology. Physicists should also support effective policy action and try to increase public knowledge of the climate crisis. Physicists can help create a more sustainable and ecologically friendly future for our world by continuing to create new knowledge and technology. The scope of their research was found to have numerous limitations by this investigation.

Keywords: energy efficiency; global warming; physics; renewable energy; science

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INTRODUCTION

The increasingly severe climate crisis seriously threatens human survival and ecosystems on Earth. Extreme climate change, rising sea levels, and increasingly frequent natural disasters require us to find effective solutions (Benevolenza, & DeRigne, 2019; Hobbie, & Grimm, 2020; Seddon et al., 2020). The climate crisis is a global challenge that challenges us to find innovative, science-based solutions (Faivre et al., 2017; Vogel et al., 2022).

The development of natural sciences, especially physics, has deepened our understanding of natural phenomena and climate change. Physics, as the basis for our

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understanding of the universe (Durante et al., 2019), has great potential to contribute greatly to solving this problem. Physicists have developed models that can predict future climate change. These models help us understand how various factors, such as greenhouse gas emissions, land use, and ocean temperature changes, influence Earth's climate. Additionally, physics is used to develop new technologies that help reduce greenhouse gas emissions and adapt to climate change (Ghil & Lucarini, 2020; Whitefoot et al., 2017). Examples include solar panels, wind turbines, and carbon capture and storage technologies. However, the role of science in addressing the climate crisis and the unfilled knowledge gaps are important questions to answer. Research that explicitly links physical concepts and practical solutions to climate change is still relatively limited.

This study aims to identify research gaps linking physics concepts and solutions to the climate crisis and highlight the importance of further research and development. This article explains the important role of science in overcoming the climate crisis. How physics is used to understand and predict climate change, and how physics is used to develop new technologies to help reduce greenhouse gas emissions and adapt to climate change.

METHOD

The method used in this research is a literature review, which collects and analyzes various reliable sources, such as scientific journals, research reports, and mass media articles relevant to global warming and physical science. Where the journals used as references for obtaining data were 15 journals consisting of national and international journals. The selection of reference sources considers the relevance of the article to the relationship between physics and climate change, the quality of the source from an accredited journal that has a good reputation, a clear and repeatable methodology, and an interdisciplinary approach that integrates physics with other disciplines such as chemistry and biology. Apart from that, articles that offer innovative solutions discuss the impact and implications of research on environmental policy, are the latest and have many citations from other researchers.

RESULT AND DISCUSSION

Van der Linden and Weber (2021) mentioned that the climate crisis is one of humanity's greatest challenges. Increasing greenhouse gas emissions cause global warming and impact many aspects of life on Earth. Based on research conducted by Bloom et al. (2022), most of the business travel emissions are from air travel, especially long-distance flights. These emissions only include the business travel of CERN employees, not the very large number of CERN users. Similarly, only the electricity used for on-site computing is included in the Scope 2 numbers, not the computing done on Grid sites outside CERN. CERN's Scope 3 emissions from 2019 and 2020 are shown in Figure 1.

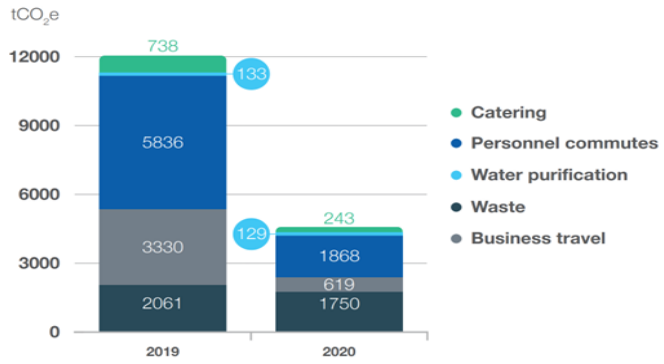

Figure 1 CERN's Scope 3 emissions from 2019 and 2020

Science, especially physics, plays an important role in understanding and overcoming this crisis. Physics helps us understand climate change's physical processes, such as the greenhouse effect, solar radiation, and atmospheric and ocean circulation (Ghil & Lucarini, 2020; Seinfeld & Pandis, 2016; Trenberth, 2020). This knowledge is important for developing effective solutions to reduce greenhouse gas emissions and mitigate the impacts of climate change.

Physics is also used to develop new technologies that reduce greenhouse gas emissions and increase energy efficiency (Pavel et al., 2024; Rahman & Khondaker, 2012). Examples include solar panels, wind turbines, and batteries. This technology can play an important role in transitioning to a low-carbon economy. Additionally, the impact of climate change on the Earth system is modelled using physics. These models can help predict the impacts of future climate change and develop effective adaptation strategies.

Understanding the Phenomenon of Climate Change

Climate change is one of the most important environmental challenges we face today. This refers to long-term changes in weather conditions on Earth, especially global warming. Here are three important aspects of climate change:

a) The Role of Greenhouse Gases in Trapping Solar Heat

Earth's atmosphere, the layer of gases surrounding the earth, plays an important role in regulating temperature. The sun continuously emits electromagnetic radiation, including visible light and infrared radiation. Most visible light passes through the atmosphere and heats the Earth's surface. However, most of the infrared radiation emitted by the earth is absorbed and re-emitted by greenhouse gases in the atmosphere. Greenhouse gases (GHG) absorb and emit infrared radiation of certain wavelengths. Natural greenhouse gases in the atmosphere include water vapour, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The greenhouse effect is an important natural process for keeping the earth warm and habitable. Without the greenhouse effect, Earth's average temperature would be much lower, and life as we know it would not be able to grow.

b) Impact of Greenhouse Gas Emissions on Earth's Temperature

Human activities increase the concentration of greenhouse gases, especially CO_2, in the atmosphere. This increase is mainly caused by burning fossil fuels such as coal, petroleum and natural gas to produce energy. Other activities, such as deforestation and agriculture, also contribute to greenhouse gas emissions (Rae et al., 2022).

An increase in the concentration of greenhouse gases in the atmosphere disrupts the natural balance of the greenhouse effect. These excess greenhouse gases absorb more of the infrared radiation emitted by the earth, trapping heat in the atmosphere and increasing global average temperatures. This phenomenon is called global warming. We are starting to feel the impact of global warming. This includes increased frequency and intensity of heat waves, changes in rainfall patterns, rising sea levels, and melting glaciers and ice sheets.

c) Prediction of Future Climate Change

Scientists use advanced climate models to predict future climate change. This model considers various factors influencing Earth's climate, including greenhouse gas concentrations, atmospheric and ocean circulation patterns, and cloud cover. Even if greenhouse gas emissions could be stopped now, global temperatures are expected to continue rising for decades. This happens because the Earth's climate system is very slow and takes time to respond to changes. The magnitude of future global warming will depend on how quickly and effectively we can reduce greenhouse gas emissions.

If emissions continue to rise, serious impacts could occur, including more frequent extreme weather events, significant sea level rise, and damage to fragile ecosystems.

The Role of Science in Overcoming the Climate Crisis

Increasing greenhouse gas emissions cause global warming and impact many aspects of life on Earth. Science, especially physics, plays an important role in understanding and overcoming this crisis. These roles include:

a) **Develop models to predict climate change**. Science is important in developing models to predict future Earth climate changes. These models are based on a scientific understanding of the physical processes underlying climate change, such as the greenhouse effect, solar radiation, and atmospheric and ocean circulation. These models allow scientists to predict the impacts of climate change, such as sea level rise, changes in extreme weather patterns, and impacts on ecosystems and food security. These projections are important for informing climate change policies and adaptation strategies. Example: Global Climate Models (GCM) and Regional Models.

b) **Utilization of technology to reduce greenhouse gas emissions**. Physics also plays an important role in developing new technologies that help reduce greenhouse gas emissions and increase energy efficiency. This technology can play an important role in transitioning to a low-carbon economy. Examples: Renewable Energy, Energy Efficiency Technologies, and Carbon Capture and Storage (CCS).

c) **Develop solutions to adapt to climate change**. Physics can also help develop solutions to adapt to the impacts of climate change that have occurred and will occur in the future. Adaptation is needed to protect humans and ecosystems from the impacts of climate change, such as rising sea levels, changes in extreme weather patterns, and loss of biodiversity. Examples: disaster early warning systems, climate-resilient infrastructure, and sustainable agricultural practices.

Development of Science Applications in Overcoming the Climate Crisis

Al Hakim (2020) mentioned that developing environmentally friendly technologies is an important way to overcome the climate crisis. These technologies aim to reduce greenhouse gas emissions, increase energy efficiency, and conserve natural resources. Below are examples of scientific applications to address the climate crisis.

a) **Solar Panels**. A solar panel is a device that converts solar energy into electrical energy. This energy can be used for various purposes, including household, industrial, and transportation purposes. Solar panels are a clean, sustainable, renewable energy source that does not emit greenhouse gases. In Indonesia, solar panels have been installed in various places, such as Bali, Lombok, and Flores.

b) **Wind Turbines**. A wind turbine is a device that converts wind energy into electrical energy. This energy can be used for various purposes, including household, industrial and transportation. Wind turbines are a clean, sustainable, renewable energy source and do not emit greenhouse gases. In Indonesia, wind turbines have been installed in West Java, South Sulawesi and East Nusa Tenggara.

c) **Carbon Capture and Storage Technology**. Carbon Capture and Storage (CCS) technology is used to capture carbon dioxide (CO_2) emissions from sources such as power plants and industrial facilities. The captured CO_2 is stored underground, preventing it from being released into the atmosphere. CCS is a promising technology for reducing greenhouse gas emissions. This technology is still developing, but several pilot projects have been launched in various countries.

d) **Water-Saving Irrigation System**. A water-saving irrigation system is designed to use water efficiently. This system helps reduce water consumption, an increasingly scarce

natural resource. Water-saving irrigation systems can also help improve food security and reduce the impact of climate change. In Indonesia, water-saving irrigation systems have been implemented in several regions, such as West Java, Central Java, and East Java.

e) **Development of Drought-Tolerant Plant Varieties**. Developing drought-tolerant plant varieties is an effort to develop plants that can grow and produce in areas with low rainfall. Drought-resistant plants can help increase food security and reduce the impact of climate change. In Indonesia, drought-resistant plant varieties have been planted in several areas, such as East Nusa Tenggara, East Java and Yogyakarta.

Mitigating the Impact of Global Warming

According to Fawzy et al. (2020), the strategy of using physics to reduce the impact of global warming can be done using several strategies, namely:

a) Develop renewable energy technology.
b) Increase energy efficiency by applying thermodynamic principles in various fields such as industry, transportation, and buildings.
c) Energy-saving measures, such as turning off lights and electronic devices when not in use, can also help reduce greenhouse gas emissions.
d) Development of CCS (carbon capture and storage) technology. CCS is a technology that captures carbon dioxide from greenhouse gas emissions and stores it underground. Physics and chemistry principles are used to develop effective and efficient CCS technology.
e) Developing Climate Models. Climate models are computer simulations used to predict future climate change impacts.

Increasing Public Awareness in Handling the Climate Crisis

Overcoming the climate crisis requires joint efforts from all stakeholders, including society. Raising people's awareness of the climate crisis and inspiring them to take action is important in addressing this problem (Wide et al., 2020). Why is raising public awareness important? Raising public awareness regarding the climate crisis is important for the following reasons:

a) **Improved Understanding**. People who understand the causes and impacts of the climate crisis will be more motivated to take action to overcome it.
b) **Changes in behaviour**. High awareness can encourage people to change their daily behavior. Such as saving energy, reducing plastic consumption and using environmentally friendly transportation methods.
c) **Public Pressure**. A society aware of the climate crisis can pressure governments and industry to take more ambitious action to combat climate change.
d) **Active Participation**. Aware communities can participate in various efforts to address the climate crisis, including reforestation, environmental education, and political advocacy.

Paglia (2018) mentioned that strategies to increase public awareness. Many strategies can be used to increase public awareness of the climate crisis. Here are some examples:

a) **Awareness Campaign**. Awareness campaigns can be conducted through various media, including mass media, social media, and educational programs in schools and communities. These campaigns can highlight the causes and impacts of the climate crisis and offer solutions to overcome it.

b) **Participatory Activities**. Communities can participate in various participatory activities to raise awareness of the climate crisis, including Examples: beach clean-ups, tree planting, and climate change workshops.
c) **The role of the media**. Mass media can help raise public awareness of the climate crisis by accurately and objectively reporting climate change news and providing a platform for experts and activists to express their opinions.
d) **Government policy**. Governments can support public awareness efforts by adopting policies encouraging climate change education and funding education and community engagement programs.

'Covering' of 1 million km2 of the Earth's area with something that substantially affects the sunlight falling on it – or the Earth's thermal re-radiation from it – might appear to be a rather ambitious task. However, since matter may be made to interact quite strongly with radiation, if its composition and geometry are properly chosen, the principal challenge is not the preparation or handling of the quantities of materials involved in this 'cover' but rather the ensuring that they will stay in place for usefully long intervals. The average 'thickness' of scattering material over this ~106 km2 is at most 10-4 cm, so that the total volume is of the order of 1012 cm3 – that of a cube 100 meters on edge – and the associated mass is 'only' of the order of 1 million tonnes. As a specific example and looking ahead to one of our results, the present concern about global warming centres on the inputting of about 7 billion tonnes of carbon into the atmosphere each year and several times this level several decades hence; the annual deployment of barely 0.01% this mass of sulfur – roughly one ten-thousandth as much sulfur as carbon – in appropriate form and location can be made to entirely offset the "greenhouse effect" of the ten-thousand-fold greater mass of added CO_2 (Mathez & Smerdon, 2018)

The symposium came out with the Islamic Declaration on Climate Change which essentially emphasized the importance of responding to Climate Change based on Islamic values and teachings. These Muslim scholars emphasize that today's climate change results from people's actions and, therefore, calls upon billions of Muslims worldwide to play a role in reducing greenhouse emissions and commit to using renewable energy sources. These scientists also emphasized that the human species, which is supposed to carry out what has been entrusted by the rulers of the earth, has become the main cause of the destruction of other creatures on this planet (Abdellah, 2020).

CONCLUSION

Physical sciences play an important role in understanding the causes and impacts of the climate crisis and developing solutions to address it. Physicists have made great progress in understanding the climate system and developing new technologies to help reduce greenhouse gas emissions. However, there is still much work to be done. Physicists must continue to work to improve our understanding of the climate system and develop new technologies that are more efficient and affordable. Additionally, physicists should work to raise public awareness of the climate crisis and support effective policy action. By continuing to develop new knowledge and technologies, physicists can contribute to building a more sustainable and environmentally friendly future for our planet. This study revealed several limitations to the scope of their research. One is the difficulty of obtaining accurate and timely data regarding the relationship between physical principles and global climate change. In addition, there is still a significant knowledge gap regarding the strategic role of science in overcoming the various challenges of the climate crisis. These limitations create challenges in providing policy recommendations based on empirical evidence.

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